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## Technical Report

No. 13225

Effects of Guayule in Tank Track Pads

Contract: DAAE 07-85-M-R010  
Firestone Project 44902  
April 1987

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By

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20020806201

A1143378

## REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188  
Exp. Date: Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION <u>Unclassified</u>		1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION / AVAILABILITY OF REPORT	
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE			
4. PERFORMING ORGANIZATION REPORT NUMBER(S)		5. MONITORING ORGANIZATION REPORT NUMBER(S)	
6a. NAME OF PERFORMING ORGANIZATION <u>Firestone Industrial Products</u>	6b. OFFICE SYMBOL (If applicable) <u>72413</u>	7a. NAME OF MONITORING ORGANIZATION <u>U.S. Army Tank Automotive Command</u>	
6c. ADDRESS (City, State, and ZIP Code) <u>1700 Firestone Blvd Noblesville, Indiana 46060</u>		7b. ADDRESS (City, State, and ZIP Code) <u>Warren, Mi. 48397-5000</u>	
8a. NAME OF FUNDING / SPONSORING ORGANIZATION <u>Department of the Army U.S. TACOM</u>	8b. OFFICE SYMBOL (If applicable) <u>AMSTA-EF</u>	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER <u>DAAE07-85-M-R010</u>	
8c. ADDRESS (City, State, and ZIP Code) <u>Warren Michigan 48397</u>		10. SOURCE OF FUNDING NUMBERS	
		PROGRAM ELEMENT NO.	PROJECT NO. <u>44902</u>
		TASK NO.	WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) <u>Effects of Guayule in Tank Track Pads</u>			
12. PERSONAL AUTHOR(S) <u>Steven W. Brunner</u>			
13a. TYPE OF REPORT <u>Final</u>	13b. TIME COVERED FROM <u>11/1984</u> TO <u>9/1986</u>	14. DATE OF REPORT (Year, Month, Day) <u>1987 April 30</u>	15. PAGE COUNT <u>13</u>
16. SUPPLEMENTARY NOTATION			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP		
19. ABSTRACT (Continue on reverse if necessary and identify by block number)			
<p>In this report the effects of Guayule rubber in tank track pads are discussed. The triblend compound from Appendix A of Mil-t-11891 Rev. C was used as the control. The two Guayule compounds evaluated were versions of the triblend in which the natural rubber and the SBR were replaced with Guayule in separate formulations. The formulations used and the physical data obtained from each are included in this report.</p>			
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION <u>Unclassified</u>	
22a. NAME OF RESPONSIBLE INDIVIDUAL <u>Jacob Patt</u>		22b. TELEPHONE (Include Area Code) <u>(313) 574-8687</u>	22c. OFFICE SYMBOL <u>AMSTA-RTT</u>

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## OBJECTIVE

The objective of this project was to determine the effects of replacing Natural rubber and Styrene Butadiene rubber with Guayule in a tank track pad compound.

## SUMMARY

The control compound used in this project was the triblend formulation from Appendix A of MIL-T-11891 Rev. C. ~~In~~ this report, this will be referred to as TS934 which is Firestone's assigned compound number. In this formulation the SBR and Natural rubber were replaced by Guayule rubber individually and were assigned the numbers TM022 and TM023 respectively. The guayule rubber was furnished by the Government through the food protein R & D Center at Texas A & M University. Various grades of Guayule were sent to Firestone that were produced by a multitude of extraction methods. The only Guayule that was used was extracted by Toluene and Methanol, and Xylene and Methanol. These two lots were blended together in equal ratios to form the two experimental batches mentioned previously.

All mixing was performed by a number eleven Farrell Banbury. The mixing specification was taken from the MIL-T-11891 Rev. C. All batches were followed by the Firestone laboratory. No significant differences were noticed in the manner in which these batches mixed. All three compounds looked very good on the drop mill just before they were put into slab form.

After the mixing was completed, these batches were extruded by means of a cold feed Extruder that was fed by a mill. The extrusions were in the form of T-142 (M60) and T-157 (M2/M3) pads.

Seventy-five pads each were cured of T-142 and T-157 for each of the three compounds. The T-142 pads were cured 70 minutes at 300°F and the T-157 pads were all cured 45 minutes at 310°F. No significant problems were encountered in curing these parts.

After curing, parts were tested for adhesion to the metal inserts. This adhesion testing evidenced no adhesion failure. (In other words, this testing showed 100% stock tear.) Results can be found in the data section.

In addition to Adhesion, other facets of testing dictated by the MIL-T-11891 Rev. C. were also conducted. (1) Complete physicals were obtained from cured slabs, as well as, from the cured parts.

The cured pads were then indentified per the contract by means of metal stamping. The TS934 (triblend compound) which is the control, was stamped "FA" on the end of the bolts. TM022 in which the Guayule replaced the SBR was stamped "FB". TM023 in which the Guayule replaced the Natural rubber was identified with the letters "FC". Also, per the contract all pads were numbered sequentially on both the T-142 and T-157 pads, from 01 through 75 on the pad plates.

These pads were then packed in wooden crates with nuts attached and shipped to the assigned destination for field test evaluations.

(1) This testing included the infrared absorption. The charts for each of the three compounds are included in this report.

## CONCLUSIONS

In replacing Natural rubber and SBR with Guayule in separate formulations very little differences were noted in mixing. The extrusions were also very similar. The cure rates were found to be similar with the TM022 (Formulation in which the SBR was replaced by Guayule) being somewhat faster curing due to the scorch safety was less than the other two. The TS934 and TM023 were nearly identical on the rheometer cure curves.

The two Guayule compounds (TM022 and TM023) were very comparable to the control with respect to physical properties. The control, however, did test higher in tensile and tear on the cured pads. This was not nearly as significant on the cured slabs for some unknown reason. On all three compounds, the cured slabs tested lower in tensile and higher in elongation. This normally indicates that the slabs may be somewhat undercured, however, since these were cured 30 minutes at 320°F, this is not believed to be the case.

The TM022 in which the SBR was replaced by Guayule tested quite low on aged elongation on the cured pad. This, however, was to be expected since the omission of the SBR should reduce the heat resistance of the compound. The Rheometer curve also demonstrated rapid reversion as compared to the other two compounds. One might expect pads fabricated from this compound to be very suspect to "blowing out" in service or in other words, undergo complete heat degradation.

The TS934 or triblend compound was the compound used for reference in the T-156 track qualification of 1985. The reference compound submitted by Firestone at that time performed extremely well. It will be interesting to see how well the Guayule compounds will fare against this previously tested compound

TABLE I

## TABULATED DATA FROM CURED SLABS AND T-142 PADS

	TS934 (L)	TM022 (1)	TM023(1)	TS934 (2)	TM022 (2)	TM023 (2)
TENSILE (PSI)	2855	2754	2753	3479	2817	3091
MODULUS @ 300% (PSI)	1336	1239	1548	2286	2365	2097
ELONGATION (%)	551	584	488	435	350	411
DUROMETER (SHORE A)	70	72	70	72	73	72

AGED 166 HRS.@ 158°F

TENSILE (PSI)	2828	2825	2643	3324	2617	2824
ELONGATION (%)	445	492	363	362	262	318
C-TEAR (PPI)	280	530	262	507	290	281
HOT C-TEAR (PPI)	267	265	205	226	183	179
LOAD COMPRESSION, % (3)	49.51	48.82	46.23	NOT TESTED	NOT TESTED	NOT TESTED
ADHESION (LBS.MIN.)	N/A	N/A	N/A	92	95	120

(1) Data taken from .075 in. slabs cured 30 minutes @ 320°F.

(2) Data taken from T-142 pads cured 70 minutes @ 300°F.

(3) Test performed on 0.500 inch buttons cured 45 minutes @320°F.

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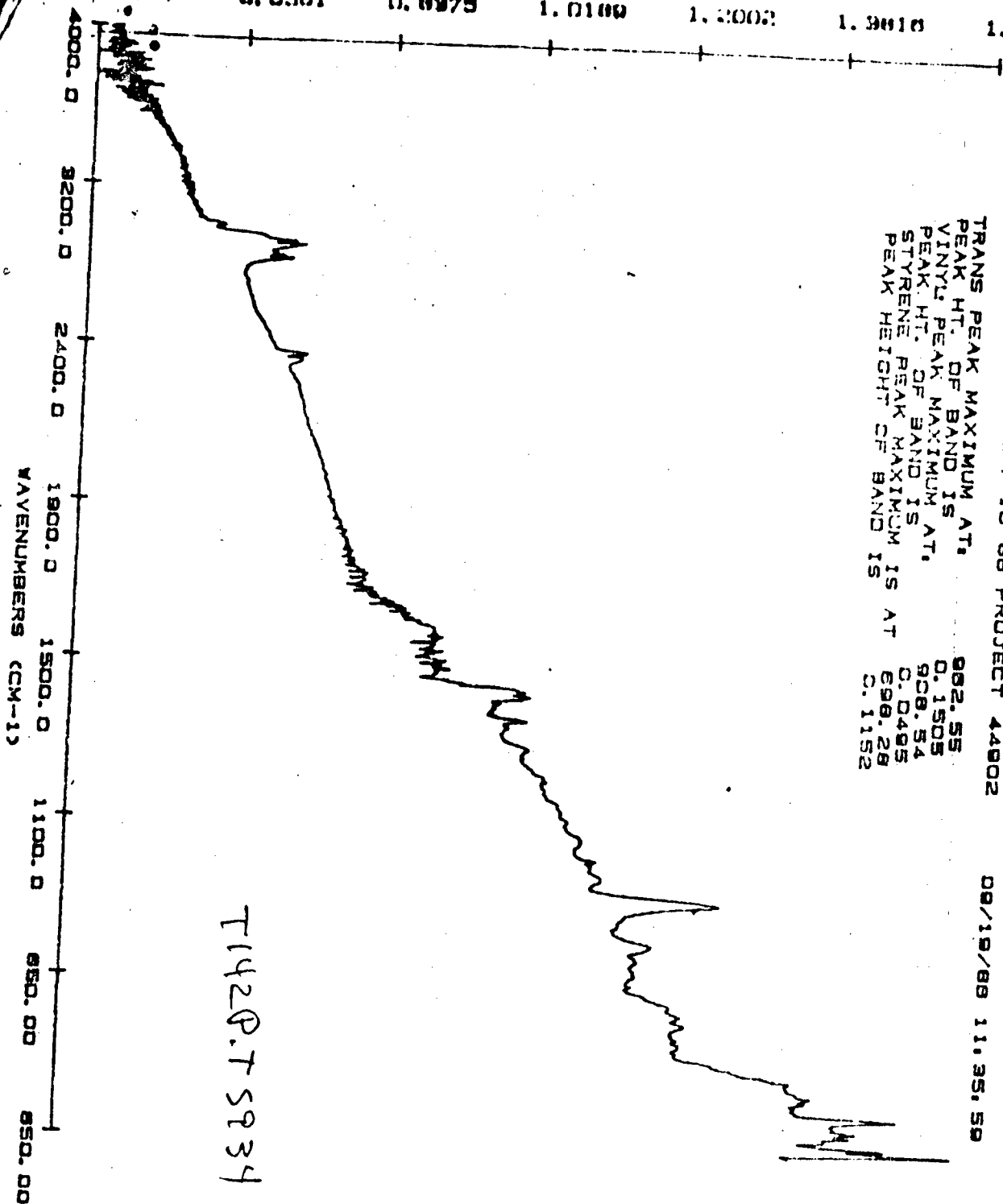
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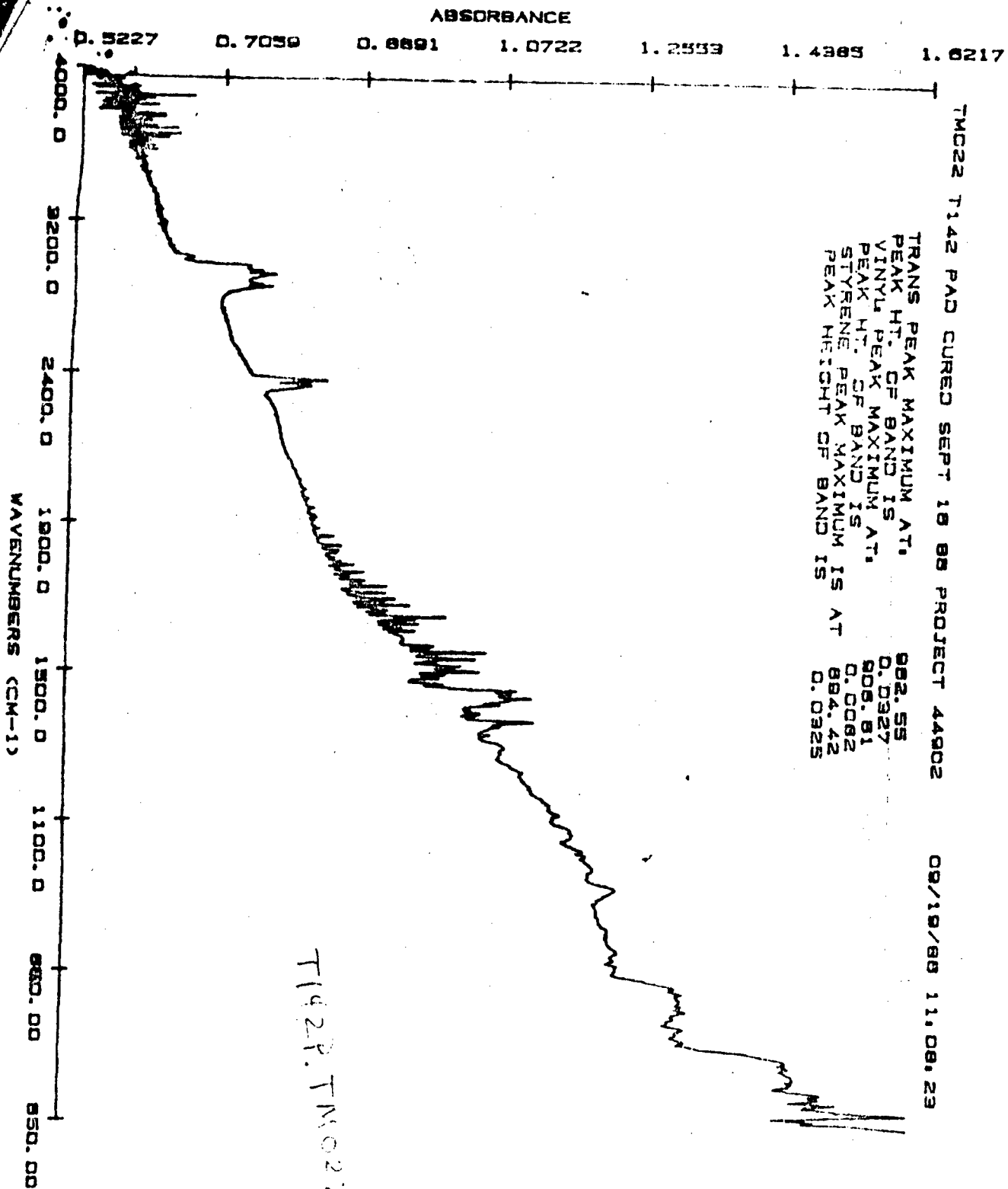
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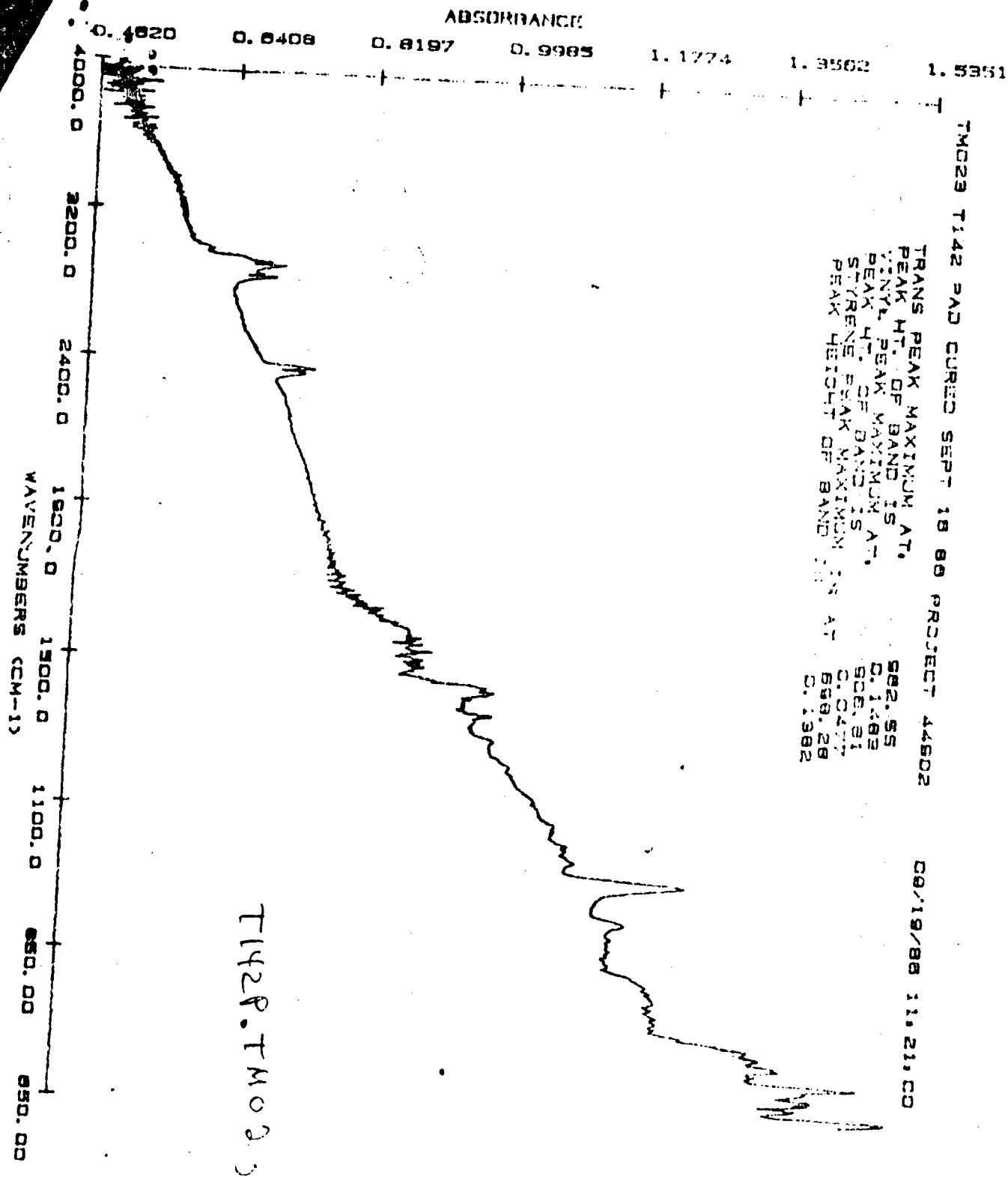
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TMO28 T142 PAD CURED SEPT 18 88 PROJECT 44602

09/19/88 11.21.00

# Firestone

MOOREVILLE, INDIANA 46030

## COMPOUND SPECIFICATION

corrected  
TS-934

USE: **MIL-T-11891 REV C Tri Blend (ground side)**

COLOR: **BLACK**

WHEEL SIZE: **5', 4', 3'**

BATCH WEIGHT: **400, 460, 470**

CYCLE TIME:

BATCH WEIGHT: **0**

COMPOUND NO.

DATE: **3/12/84**

COMPUTER NO.

REPLACE: **14A**

COMPOUND NO.

**S P HAAS**

CODE	MATERIAL	100 RHC FORMULA		BANSBURY #		%
		WEIGHT	VOLUME	WEIGHT	WEIGHT	
<b>5539 MB</b>	SEB POLYMER	35.00		90.00		18.
	DIENE POLYMER	30.00		77.00		16.
	NATURAL POLYMER	35.00		90.00		18.
	N220 CARBON BLACK	45.00		116.00		24.
	ZINC OXIDE	3.00		7.72		1.
	STEARIC ACID	1.50		3.86		.
	FLECTOL FLAKES	2.00		5.14		1.
	SUNDEX 790	4.00		10.28		2.
		155.50		400.00		
<b>5540 MB</b>						
<b>5539 MB</b>	1st master batch	155.50		397.50		
	N220 carbon black	20.00		51.00		10.
	Santorflex 13	3.00		7.67		1.
	Sunolite 100 wax	1.50		3.83		.
		180.00		460.00		
<b>TS934</b>						
<b>5540 MB</b>	2nd master batch	180.00		458.04		
	sulfur	1.30		3.31		.
	Santocure IPS	3.20		8.14		1.
	PVI	0.20		.51		.
<b>TOTALS</b>		184.70		470.00		100.

REMARKS: (REASON FOR CHANGE, SPECIAL INSTRUCTIONS, ETC.)

CONTROL COMPOUND FOR T156 TANK TRACK (GROUND SIDE) AS

SPECIFIED IN U.S. GOV'T. SPEC MIL-T-11891 Rev C(compound 14A)

B. F. 2/57

2.55

2.54

CONTROL TEST REQUIREMENTS			STANDARD PHYSICALS	
TEST	STANDARD	FREQ.		
ENDOGRAPH	SEE CHART		100% MOD.	
DISPLETION			100% MOD.	
COLOR	SEE SPECIMEN		TENSILE	2000
HARDNESS (DUNDA)	1		ELONGATION	2900
TENSILE (PSI)	MIN.		HARDNESS	400
ELONG (S)	MIN.		SP. GRAVITY	72
MODULUS (PSI)				1.14
SPECIFIC GRAVITY	1			
LOW TEMPERATURE				
VISCOSITY				
B. C. BUTTER FUEL				
	MIN. 0			

# Firestone

MOOREVILLE, INDIANA 46060  
COMPOUND SPECIFICATION

USE: T-142 - T-157 Pads  
COLOR:  
MIXING TIME: 5' - 4' - 3' BATCH WEIGHT @  
CYCLE TIME: BATCH WEIGHT @

COMPOUND NO. TM022

RACE TEMPORARY

DATE: 12-5-84

COMPUTER NO.

REPLACES: New

COMPOUNDED

C. W. Murphy

CODE	MATERIAL	100 RHC FORMULA		BANSBURY #		BANSBURY #	%
		WEIGHT	VOLUME	WEIGHT	WEIGHT		
5639							
	Guayle Rubber	35.		90 00			18.95
	Diene Rubber	30.		77 00			16.25
	Natural Rubber	35.		90 00			18.95
	N-220	45.		116 00			24.38
	Zinc Oxide	3.		7 72			1.62
	Stearic Acid	1.5		3 86			.81
	Flectol Flakes	2.		5 14			1.08
	Sundex 790	4.		10 28			2.16
		155.5		400 00			
5640							
5639		155.5		397 5			
	N-220	20.		51 00			10.83
	Santoflex 13	3.		7 67			1.62
	Sunolite 100	1.5		3 83			.81
		180.		460 00			
TM022							
5640		180.		458 04			
	Sulfur	1.3		3 31			.30
	Santocure IPS	3.2		8 14			1.73
	Santogard PVI	.2		51			.11
TOTALS		184.7		470 00			100

REMARKS: (REASON FOR CHANGE, SPECIAL INSTRUCTIONS, ETC.)

B. F.

Reference solicitation DAAE07-85-Q-X803

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Reference paragraph C.1.2

2.54

CONTROL TEST REQUIREMENTS			STANDARD PHYSICALS	
TEST	STANDARD	PROD.		
RHEOGRAPH	ENE CHART		100% MOD.	
DISPERSION			200% MOD.	
COLOR	LEN SPECIMEN		TENSILE	
HARDNESS (DUROA)	±		ELONGATION	
TENSILE (PSI)	MDL		HARDNESS 72	
ELONG (%)	MDL		SP. GRAVITY 1.14	
MODULUS (PSI)				
SPECIFIC GRAVITY	±			
LOW TEMPERATURE				
VISCOSITY				
Q. C. BUTTON CURE:	MIN. @			
Q. C. SLAR CURE:	MIN. @			



NOBLESVILLE, INDIANA 46060

## COMPOUND SPECIFICATION

COMPOUND NO. TM023

BASE TEMPORARY X

DATE: 12-5-84

COMPUTER NO.

REPLACES: New

COMPOUNDED C. W. Murphy

USE: T-142 - T-157 Pads

COLOR:

MIXING TIME: 5'-4'-3' BATCH WEIGHT #

CYCLE TIME: BATCH WEIGHT #

CODE	MATERIAL	100 RHC FORMULA		BANDURY #		BANDURY #	%
		WEIGHT	VOLUME	WEIGHT			
5641							
	SBR Polymer	35.		90	00		18.95
	Diene Polymer	30.		77	00		16.25
	Guayle Rubber	35.		90	00		18.95
	N220	45.		116	00		24.38
	Zinc Oxide	3.		7	72		1.62
	Stearic Acid	1.5		3	86		.81
	Flectol Flakes	2.0		5	14		1.08
	Sundex 790	4.0		10	28		2.16
		155.5		400	00		
5642							
5641		155.5		397	5		
	N-220	20.		51	00		10.83
	Santoflex 13	3.		2	67		1.62
	Sunolite 100	1.5		3	83		.81
		180.0		400	00		
TM023							
5642		180.		458	04		
	Sulfur	1.3		3	31		.70
	Santocure IPS	3.2		8	14		1.73
	Santogard PVI	.2		51			.11
TOTALS		184.7		470	00		100.

REMARKS: (REASON FOR CHANGE, SPECIAL INSTRUCTIONS, ETC.)

B. F.

Reference Solicitation DAAE07-85-Q-X803

Reference paragraph C.1.3

2.57

2.55

2.54

CONTROL TEST REQUIREMENTS			STANDARD PHYSICALS	
TEST	STANDARD	REQ.		
ENEGRAPH	SEE CHART		100% MOD.	
DISPERSION			300% MOD.	
COLOR	SEE SPECIMEN		TENSILE	
HARDNESS (DURDA)	±		ELONGATION	
TENSILE (PSI)	MIN.		HARDNESS	72
ELONG (%)	MIN.		SP. GRAVITY	1.14
MODULUS (PSI)				
SPECIFIC GRAVITY	±			
LOW TEMPERATURE				
VISCOSITY				
Q. C. BUTTON CURE:	MIN. @			
Q. C. SLAB CURE:	MIN. @			

COMPOUND NO.

(13)